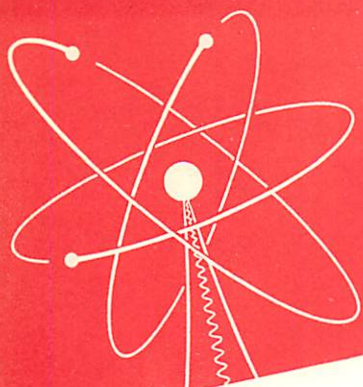

TV SYNC SIGNALS

Lesson T2C-9A

DeVRY Technical Institute
4141 W. Belmont Ave., Chicago 41, Illinois
Formerly DeFOREST'S TRAINING, INC.

T2C-9A

SYNC SIGNALS

ELECTRONICS TELEVISION
DTI
DeVRY Technical Institute

4141 Belmont Ave.
Chicago 41, Illinois

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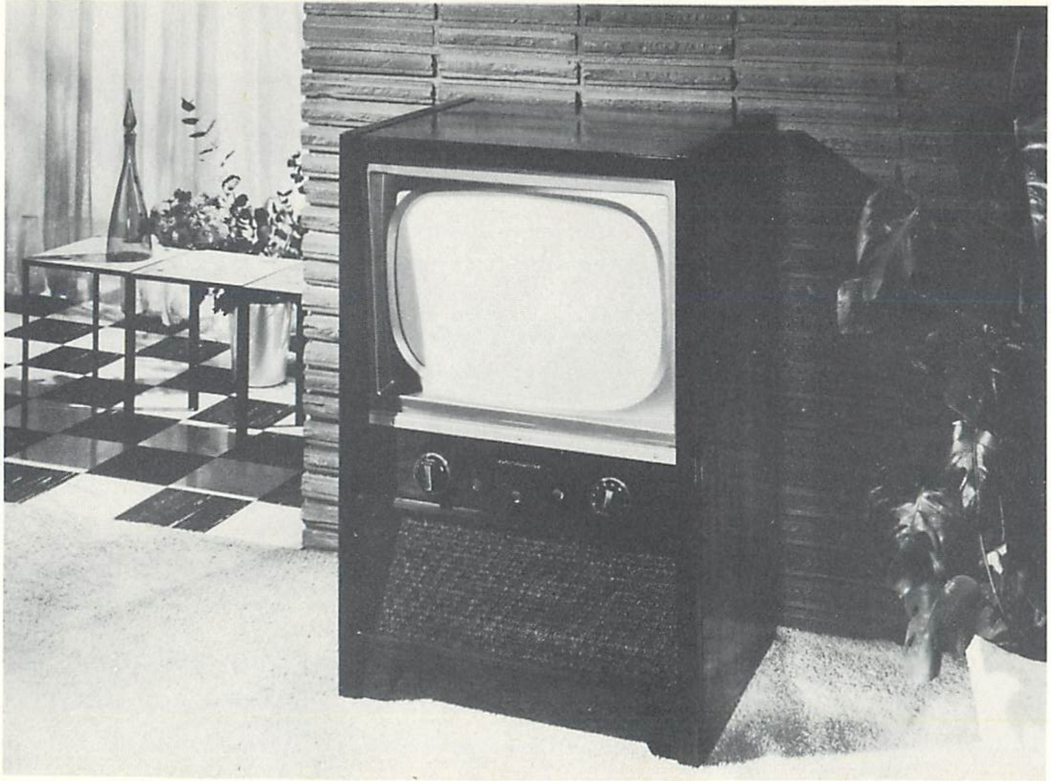

This console model television receiver employs an aluminized 21-inch picture tube. The safety glass in front of the tube is tinted to prevent room light reaching the screen. Sound is produced by a 10″ bass speaker and a 4″ treble speaker.

Courtesy Raytheon Mfg. Co.—TV & Radio Operations

SYNC CIRCUITS

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> **A man's mind may be likened to a garden, which may be intelligently cultivated or allowed to run wild; but whether cultivated or neglected, it must and will bring forth.**
>
> **—James Allen**

SYNC SIGNALS

NEED FOR SYNC SIGNALS

If the transmitted image is to be reproduced properly on the screen of the television receiver, the cathode ray beam in the picture tube must be exactly in step with the electron beam in the camera tube at the transmitting studio. Therefore, in addition to the picture and sound signals, a third signal is included in the total information radiated from transmitter to receiver. Called the synchronizing signals, a series of pulses is added to the picture signal to form the complete video signal. This complete or composite video signal amplitude modulates the picture carrier. That is, the same carrier is employed to transmit both the picture and synchronizing signals, while the sound carrier conveys the sound signals only.

The synchronizing signals cause the electron beam to begin scanning at the top of the receiver screen at the same instant that the camera tube beam is beginning its scan at the top of the electron image on its image plate or target. Also, these signals cause the picture tube beam to begin each horizontal trace at the instant the corresponding line scan is beginning in the camera tube. Due to these controlling actions, every detail on the receiver screen has the same location in the reproduced image as in the scene at the studio, and the beams in the respective tubes reach the end of the last line at the same instant. At this point, a sync pulse causes each to return to the top of the image or screen to begin the next field. Without these controlling sync pulses, only a meaningless jumble of rapidly shifting light and dark areas is produced on the screen of the receiver.

SOURCE OF SYNC SIGNALS

The synchronizing signals consist of rectangular pulses of a specified amplitude and length or duration. To control the side-to-side movements of the beams, pulses 5 microseconds in duration are spaced 58 microseconds apart. These are called the horizontal sync pulses. Thus, the time from the beginning of one line scan to the beginning of the next is a total of 5 + 58 or 63 microseconds.

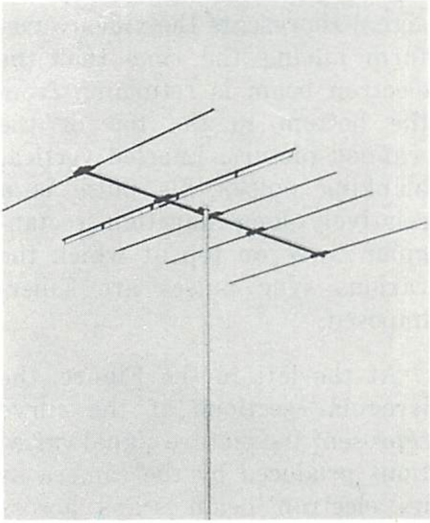
The up-and-down movements of the beams are controlled by a series or group of six vertical sync pulses. A group of these vertical sync pulses occurs at the end of each field scan. Within the group, each individual pulse has a duration of 27 microseconds, and the pulses are spaced about 4.5 microseconds apart.

A third type of sync pulse, the equalizing pulse, has a duration of 2.5 microseconds. Spaced 29.2 microseconds apart in groups of six, these pulses occur just before and just after the six vertical pulses. Their purpose is to determine the exact location of the scanning lines of a field relative to those of the preceding field.

These various sync pulses are produced at the television station by the synchronizing signal generator which consists of a combination of electron tube circuits including square wave or pulse generators, shapers, timing circuits, and keyers. These circuits provide the various sync pulses mentioned, and combine them in the proper sequence to form the composite synchronizing signal.

The common arrangement of the television studio and transmitter equipment is shown in Figure 1. Starting at the left, the camera output is amplified and applied to the modulator, a power amplifier. The picture carrier is produced by the carrier generator and applied to the modulated r-f amplifier. In this stage, the modulator video output amplitude modulates the r-f carrier to produce the final form of the wave to be radiated by the transmitting antenna.

The synchronizing signal generator is shown at the lower left in Figure 1, and its sync pulse output is applied to the camera to control the movements of the electron beam in the camera tube. Also, as indicated, the sync generator output is coupled to the video amplifier. Here, the sync signal combines with the picture signals from the camera to form the composite video signal.



Both the picture and synchronizing signals modulate the r-f video carrier picked up by the receiving antenna.

Courtesy Channel Master Corp.

COMPOSITE VIDEO SIGNAL

The wave-form of the composite video signal is shown in Figure 2. Although explained in an earlier lesson, this wave-form is repeated here for review. To include all the types of sync pulses in the drawing, this example shows the video wave-form which is produced during the brief period in which the electron beam traces the last four lines at the bottom of the picture, returns quickly to the top of the screen, and then traces the first four lines of the next field. Thus, only eight lines of the picture signal are included here, four at each side of the drawing. The central portion of the composite signal represents the video waveform during the time that the electron beam is returning from the bottom to the top of the scanned picture. Labeled vertical blanking pulse, this pulse is a relatively long duration rectangular wave on top of which the various sync pulses are superimposed.

At the left in the Figure, the irregular sections of the curve represent the picture signal variations produced by the camera as its electron beam scans across the target. At the end of each scan or line, a blanking pulse is applied to reduce the beam intensity to zero during the retrace interval. In Figure 2, a horizontal blanking pulse follows each scanning line interval. These blanking pulses are produced by the sync generator also, and applied along with the sync pulses to the camera and video amplifier, Figure 1.

On top of each horizontal blanking pulse, Figure 2, is a horizontal sync pulse. After the last line of the picture is scanned, the vertical blanking pulse reduces the beam intensity to zero during the vertical retrace interval. As shown, the equalizing and vertical sync pulses occur during this period, as well as a number of horizontal sync pulses. After the beam reaches the top of the picture, the vertical blanking pulse drops to zero, and the scanning of the first line begins.

At the extreme left in Figure 2, the various signal levels are indicated. The picture signals vary between the reference black and reference white level. The blanking pulses have greater amplitude than any of the picture signals, and therefore rise above the reference black level. Of even greater amplitude, the sync pulses rise above the blanking level. These amplitude differences are necessary to permit separation of the sync and picture signals at the receiver. Here, the entire composite video signal is applied to the picture tube.

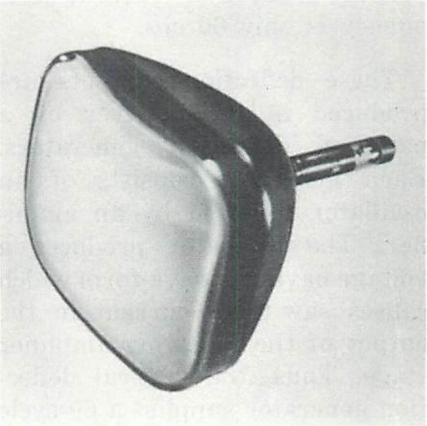
During both the horizontal and vertical retrace intervals, the blanking pulses reduce the spot brightness to black. Since they occur during these intervals, the sync pulses do not interfere with the picture. However, the picture signals must be removed from the composite signal before the sync signals are applied to the receiver deflection circuits.

USE OF SYNC SIGNALS IN RECEIVER

The picture on the receiver screen consists of an orderly arrangement of light and dark areas produced by deflecting the electron beam over the inner surface of the picture tube face. A tiny spot of light is produced at the point where the beam strikes the screen, and the beam moves from side to side so that the spot traces the horizontal lines. At the same time, the spot moves relatively slowly from top to bottom of the screen so that successive lines are traced under each other. These combined actions result in a pattern of closely spaced, thin horizontal lines. Called the raster, this pattern has the general appearance of a grid. With the video signal applied to the control grid or cathode of the picture tube, the moving spot of light varies in intensity to provide an over-all reproduction of the televised scene.

As explained previously, magnetic deflecting fields bend the beam of electrons to provide the desired scanning action. Reviewing briefly, two pairs of coils, formed into an assembly called the yoke, are mounted around the outside of the picture tube neck. One pair of the coils produces a magnetic field which varies in intensity at a rate of 60 cycles a second. Called the vertical deflection coils, this pair causes the top-to-bottom movement of the electron beam on the screen. The side-to-side movement is caused by the other pair, the horizontal deflection coils, which produce a magnetic field varying in intensity at a rate of 15,750 cycles per second.

For both pairs of deflection coils, the varying magnetic fields are the result of currents in the coils. These deflection currents are alternating currents which have saw-tooth wave-forms. Because of this wave-form, the resulting magnetic fields change at a steady rate in one direction over a long period of time, and then change rapidly in the other direction for a relatively short interval. Due to this change in



To properly reproduce the transmitted scene, the electron beam in the receiver picture tube is synchronized with the beam in the camera tube at the studio.

Courtesy Sylvania Electric Products, Inc.

field strength and direction, the beam is moved steadily from left to right by the field of the horizontal coils to produce the horizontal lines on the screen, and snapped quickly back to the left as each line is completed.

Also, the beam is moved steadily from the top to the bottom of the screen by the field of the vertical coils, and then snapped quickly back to the top. The large number of horizontal lines produced by the horizontal coils during each complete cycle of vertical movement is due to the fact that the horizontal deflection current frequency is 15,750 cps while the vertical deflection current frequency is only 60 cps.

These deflection currents are produced in the receiver by a pair of deflection generators. Each generator consists of an oscillator followed by an amplifier. The oscillator produces a voltage having a wave-form which causes saw-tooth current in the output of the following amplifier stage. Thus, the vertical deflection generator supplies a 60 cycle saw-tooth current, and the horizontal deflection generator a 15,750 cycle saw-tooth current to the respective deflection coils. #3 Removed from the composite video signal, the vertical and horizontal sync pulses control the oscillation frequency of the respective deflection generators. In this way, the picture tube beam movements are kept in step with the movements of the scanning beam in the camera tube in the studio.

The various signal paths are shown in the block diagram of a receiver in Figure 3. Converted to intermediate frequencies by the tuner, the picture and sound carriers pass through the i-f amplifier to the video detector. This stage demodulates the picture carrier, and produces the 4.5 mc sound i-f carrier. The v-f amplifier increases the strength of video signal and sound i-f, and passes the latter to the sound channel.

A second output point from the v-f amplifier applies the video signal to the control grid or cathode of the picture tube. The third output point couples the video signal to the sync circuits represented by the large block at the lower left. The use of separate output points for the video signal in the v-f amplifier plate circuit prevents attenuation of the picture signal by the input capacitance of the sync circuits.

Described in this and the following lesson, the sync circuits separate the sync pulses from the picture and blanking pulse portions of the composite video signal. In addition, these circuits separate the low frequency vertical sync pulses from the high frequency horizontal sync pulses.

As indicated in Figure 3, the 60 cycle per second sync pulse output is applied to the vertical saw-tooth generator, while the 15,750 cycle pulses are applied to the circuits which produce saw-tooth current for the horizontal deflection. The operation of these saw-tooth (S.T.) generators is explained in lessons to follow. As shown, the 60 cycle saw-tooth current passes through the vertical coils of the deflection yoke, and the horizontal deflection coils carry the 15,750 cycle saw-tooth current. These currents produce magnetic fields which pass through the glass tube wall and deflect the electron beam by interacting with the magnetic field about the beam as explained previously.

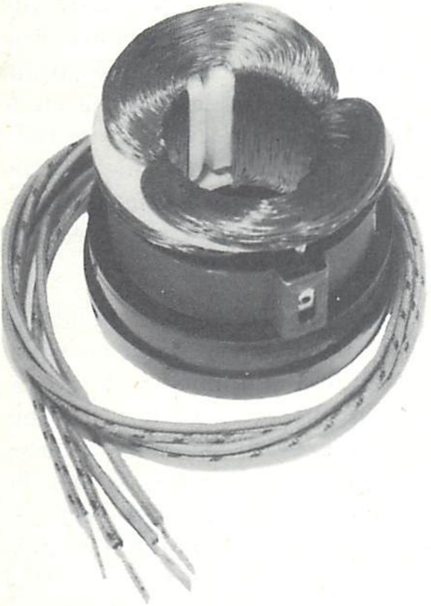
In Figure 3, the saw-tooth wave-form above the picture tube neck indicates the gradual rise and rapid fall of the vertical deflecting current. During the long gradual rise, the beam moves steadily from the top to the bottom of the screen. It returns quickly to the top during the sharp fall of current in the deflection coils. Several cycles of the horizontal saw-tooth current are represented by the wave-form below the picture tube neck. In this case, the beam moves from left to right to trace a line during each gradual rise of current, and returns quickly to the left side of the screen when the current falls.

SYNCHRONIZING THE HORIZONTAL SWEEP

Figure 4A shows the video signal applied to the electron gun of the picture tube during one complete cycle of the horizontal deflection action. The saw-tooth represents the current wave-form in the horizontal deflection coils. Approximately 55½ microseconds are required for the gradual rise during which time the beam moves from the left to the right side of the screen. The beam then returns to the left side of the screen in about 8 microseconds for a total of 63½ microseconds for the cycle.

The picture signal variations show the polarity required when this signal is applied to the cathode of the picture tube. In this case, the beam intensity reduces when the video signal swings the cathode positive, since this is equivalent to swinging the grid negative. At the extreme left of the picture signal, the short horizontal line is a portion of the preceding blanking pulse. This pulse has reduced the beam intensity so that the spot is not visible for a brief interval at the beginning of its left to right sweep. At point e_1, the blanking pulse is removed and the beam intensity increases to make the spot visible. From here to point b, the picture signal varies the beam intensity to produce the various tones of gray corresponding to the picture details. At point b, a horizontal blanking pulse again reduces the spot intensity to the black region.

A short time later, at point c, the horizontal sync pulse is applied to the horizontal deflection circuits to start the rapid fall of deflection current. In the interval between points c and d, the beam returns to the left side of the screen, and the blanking pulse keeps the spot invisible so that it does not trace a line on the screen during its return trip. At point d, the beam again begins to move to the right, and at point e the blanking signal is removed to allow the picture signal to produce the next line of picture information.



To produce the magnetic field required to deflect the beam over the picture tube screen, a deflection yoke like the one shown here carries saw-tooth currents generated by the deflection circuits.

Courtesy Merit Coil & Transformer Corp.

Thus, in the cycle just described, the trace is visible to produce a line of the picture between points e_1 and b, while blanking pulses make the spot invisible #4 during the retrace time, and at the extreme ends of the left to right movement. The sync pulse determines the instant at which #5 the "forward" trace ends and the retrace begins.

The total horizontal blanking time is standardized at slightly over 10 microseconds. That brief period of blanking from points b to c, which precedes the sync pulse, is referred to as the "front porch" of the pulse signal, while that portion after the sync pulse is the "back porch" of the blanking pulse.

Figure 4B represents several scanning lines and shows the relationship of the trace and retrace portions of the horizontal deflection cycle to the picture and raster edges. For example, point e_1 on the saw-tooth wave-form in Figure 4A coincides with the end or "trailing edge" of a horizontal blanking pulse, and the beginning of the visible portion of the trace. As indicated in Figure 4B, this is the left edge of the picture.

Point b coincides with the leading edge of the next horizontal blanking pulse, and the end of the visible trace. This is the right edge of the picture as shown in Figure 4B. Point c corresponds to the leading edge of the horizontal sync pulse which initiates the retrace action. This is the end of the complete trace period and the right edge of the raster. Since the beam is blanked out during the period from b to e, the extreme edges of the raster are invisible.

In Figure 4B, point d is the end of horizontal retrace action by which the beam is brought back to the left side of the screen. This beginning of the next trace period is the left edge of the raster. Point e coincides with the trailing edge of the horizontal blanking pulse and the beginning of the visible portion of the next horizontal line of picture information.

Figure 5 shows the composite video signal over a period of several cycles of horizontal scanning and part of the vertical blanking interval. At the top left, the seven lines of picture signal are interrupted periodically by the horizontal blanking and sync pulses. At point b, the end of the seventh line, the vertical blanking pulse reduces the spot intensity to black, and maintains it thus during the entire time that the beam returns from the bottom to the top of the screen.

Near the center of Figure 5, a series of saw-tooth cycles indicates the wave-form of the horizontal deflection current. At the lower part of the Figure, an inverted saw-tooth wave-form indicates the vertical deflection action. That is, it represents the fact that the beam moves gradually downward on the screen while successive horizontal lines of picture information are reproduced, and after being blanked at point b, continues downward until time instant t. At this point, the vertical sync pulses produce a voltage of sufficient amplitude to trip the vertical deflection oscillator and thus produce a rapid fall of current in the vertical coils of the yoke. This action produces the vertical retrace; that is, returns the beam to the top of the screen as indicated at the lower right in the Figure. The vertical deflection wave-form in Figure 5 is drawn as a heavy line to indicate when the spot is visible (except the brief horizontal blanking intervals), and light to indicate when the spot is blanked out by the vertical blanking pulse.

As shown between points b and t, about five cycles of horizontal deflection occur while the beam is still traveling downward. After point t, the beam moves upward, but continues its side-to-side movement as well. In Figure 5, the vertical dashed lines show that a horizontal sync pulse corresponds to the beginning of each retrace portion of the horizontal deflection action. Although there are no horizontal sync pulses during the portion of the vertical blanking interval shown in the Figure, every second equalizing pulse and vertical sync pulse serves to keep the horizontal deflection oscillator in synchronism during this time. This condition is indicated by dashed lines drawn between the leading edges of these pulses and the peaks of the horizontal saw-tooth wave-form.

In practical use, the raster dimensions are adjusted by the receiver size controls so that the blanked portions at the sides, top, and bottom of the raster are behind the edges of the mask mounted in front of the picture tube.
Courtesy RCA Service Co., Inc.

SYNCHRONIZING THE VERTICAL SWEEP

Figure 6 shows how two successive fields of the composite video signal correspond in time with the two cycles of vertical deflection required to complete the frame. As noted at the top of the Figure, a total of 525 horizontal deflection cycles occur during this one frame period.

Points u and v at the upper left indicate the portion of the signal described for Figure 5. Thus, beginning where Figure 5 left off, point v in Figure 6, the saw-tooth curve shows the beam continues its upward motion for most of the vertical blanking period, but starts downward before this period is ended. The vertical deflection action causes the beam to continue downward to point 3, upward to point 4, downward to point 7, upward to point 8, and so on. Notice these points are circled for ease in locating them on the diagram.

The various numbered points in Figure 6 correspond to those in Figure 7 which shows the path of the spot on the picture tube screen. Thus, referring to both Figures, at point 1, the vertical blanking pulse ends and the spot becomes visible. This point is the beginning of the first "active" horizontal scanning line at the top of the picture. As indicated by the heavy line 1 in Figure 7, the visible spot moves to the right at a downward slant from point 1. Arriving at the right edge of the raster, the spot reverses direction and returns to the left, blanked out by the horizontal blanking pulse, as indicated by the dashed line. It then moves to the right again to trace the next line.

After about 242½ of these horizontal cycles, the spot arrives at point 2 where it is blanked out by the vertical blanking pulse. As shown in Figure 6, the spot continues downward to point 3. During the period from point 2 to point 3, several more horizontal cycles are completed as shown by the dashed lines in Figure 7.

At point 3, the vertical sync pulse causes the vertical deflection to reverse direction which also corresponds to point t, Figure 5, and the spot starts upward as shown in both Figures 6 and 7. During the vertical retrace, the invisible spot moves upward much faster than it moved during its top-to-bottom deflection. However, several horizontal cycles occur during the vertical retrace time between points 3 and 4. Therefore, as shown in Figure 7, the spot travels at a slant upwards from point 3 to the right side of the screen, then from side to side a few times until it finally arrives at point 4 at the top center.

Figure 6 shows that, at point 4, the spot again starts downward, but remains invisible until it reaches point 5. During the time between points 4 and 5, a number of horizontal cycles occur, also indicated by the dashed lines at the top of Figure 7. Notice that point 5 is on a level with point 1, and therefore corresponds to the top of the picture also.

At point 5 in the middle of the screen, the vertical blanking pulse is removed and the spot becomes visible to begin tracing the active or "useful" horizontal scanning lines of the second field.

Moving to the right and downward from point 5, the visible spot has traveled only one-half the raster width when it reaches the right edge of the screen. Therefore, it also has moved downward only one-half as far as it does when it travels the entire width of the raster. Consequently, when it returns to the left side of the screen, as shown by the dashed line, it is in position to trace a line midway between the first two lines of the previous field. Thus, it moves to the right along the heavy line immediately under the one that began at point 1.

For each succeeding horizontal cycle, the spot moves downward a distance such that it skips the lines traced by the first field, and traces the second field of lines so that they fall between or interlace the first field lines.

After approximately another $242\frac{1}{2}$ useful scanning lines, the spot arrives at point 6, at the lower right in Figure 7, where it is blanked out by the vertical blanking pulse as indicated in Figure 6. Again, a few more horizontal cycles occur until the beam reaches point 7. Here, the vertical sync pulse reverses the direction of vertical deflection to start the spot upward for its second vertical retrace motion.

As shown in Figure 7, the spot moves upward and to the right until it reaches the right edge of the raster, back to the left side, then upward at a slant to the right side, and so on up to point 8.

At point 8, the spot starts downward but remains invisible until it arrives at point 1 in Figure 7. This point is designated point 1 in Figure 6 because it represents the start of the next frame. From this point, the spot moves down the screen again, retracing the same scanning lines that were traced during the first field of the complete frame just described.

Notice that point 7 corresponds with point t located near the left edge of Figure 6. In Figure 5, point t denotes the instant the vertical sync pulses initiate vertical retrace action. This reversal of vertical deflection occurs between points r and s of one of the inactive horizontal deflection cycles, just before the end of its left to right trace motion.

This action of the vertical retrace starting during the last portion of a horizontal forward trace is shown in Figure 7 at point 7, where the vertical retrace line begins. Here, as the spot moves upward, it also travels for a short time to the right until horizontal retrace occurs. Thus, the over-all vertical retrace pattern is the result of horizontal trace and retrace occurring during vertical retrace.

In Figure 6, points w and x at the upper center include the last few lines of the first field, a vertical blanking period, and the first few lines of the second field. At the right, points y and z include the last few lines of the second field, a vertical blanking period, and the first few lines of the first field of the next frame.

The section between w and x is expanded in Figure 8A, and that between y and z is shown in Figure 8B. The numbered points in Figure 8 correspond to those in Figures 6 and 7. Thus, at the left side of Figure 8A, point 2 represents the point where the vertical blanking pulse blanks out the spot at the middle of the last line of the first field.

After the equalizing pulse interval, the six vertical sync pulses occur. A given receiver can be adjusted so that the vertical deflection will be reversed at almost any point during the vertical sync pulse interval. Once set, it is the same for every field. Thus, assuming this point is at the end of the fourth pulse, as in previous examples, the wave-forms of Figures 8A and 8B are drawn so that this point is directly over points 3 and 7 of the vertical deflection wave-form in Figure 8C. At the lower part of Figure 8A, and the upper part of Figure 8B, saw-tooth wave-forms represent the horizontal deflection cycles occurring during the periods from w to x and y to z.

At point 3, Figure 7, the invisible spot reaches its lowest point on the screen and starts upward. This point occurs at the middle of a line, and is indicated in Figure 8A by the dashed vertical line which intersects the horizontal deflection wave-form near the middle of the rising portion of a saw-tooth wave.

At point 4, the spot reaches the highest point on the screen and starts downward. The vertical blanking pulse ends at the middle of a horizontal cycle as indicated by the vertical dashed line at point 5, Figure 8A.

Point 5 is the beginning of the second field of active scanning lines, as explained for Figures 6 and 7. These lines continue to the bottom of the picture where the spot is blanked out by the vertical blanking pulse at point 6, Figure 8B. At point 7, the vertical sync pulse action causes the vertical deflection to reverse direction and the beam starts upward. A com-

The type 12AU7 twin triode is typical of the tubes employed in the sync sections of television receivers.

Courtesy General Electric Co.

plete vertical deflection cycle occupies 1/60th of a second, or approximately 16,667 microseconds.

Since each horizontal deflection cycle is approximately 63½ microseconds in duration, a total of 16,667 ÷ 63½, or 262½ horizontal cycles occur from point 3 in Figure 8A to point 7 in Figure 8B. Notice that the half cycle begins at point 3. Therefore, after this half cycle is completed, 262½ cycles occur to end the field at point 7, at the end of a full line.

The spot reaches the top of the screen at point 8, and starts downward, with the active scanning lines beginning at point 1 to start the next frame. From point 7, 262½ horizontal cycles occur during the next 1/60th of a second, so that the next vertical retrace action begins in the middle of a horizontal line. This point corresponds to point 3 in Figure 8A.

The two cycles of vertical deflection divide the 525 horizontal deflection cycles of a complete frame into two groups of 262½ cycles each. As explained, this action results in the scanning lines of the second field being displaced vertically on the screen so they fall between the lines of the first field. This half-line displacement is indicated in Figure 8 where the vertical dashed lines intersect the middle of the saw-tooth rise in Figure 8A and the peaks of the saw-tooth wave-forms in Figure 8B.

SYNC SEPARATORS AND AMPLIFIERS

Before the sync pulses can be applied to the respective horizontal and vertical deflection circuits, they must be separated from the complex video wave. In addition, these sync pulses pass through filter networks designed so that only pulses at 15,750 cps are applied to the horizontal deflection circuit, and 60 cycle pulses are applied to the vertical deflection circuit.

The receiver stages which remove or strip the high amplitude sync pulses from the composite video signal are called **sync separators, clippers,** or **strippers.** Various types of tubes are employed for this purpose, but the basic principle used in each case consists of biasing the tube so that it cannot conduct plate current for video signal components of blanking pulse amplitude or lower. Since the sync pulses have an amplitude greater than the blanking level, they overcome the bias and cause plate current in the separator tube to produce a pulse output.

#8

Triode Sync Separator

Figure 9B shows the circuit of a sync separator employing a triode tube. The cathode is grounded, and grid leak bias developed by C_1 and R_1. Applied to the grid, input signal e_i must have the polarity shown in Figure 9A. That is, the sync pulses must be the most positive part of the wave-form. As in all grid leak bias arrangements, the positive peaks of input signal e_i drive the grid positive with respect to the cathode to allow short pulses of cathode-to-grid electron flow.

These pulses of electron flow charge capacitor C_1 to the polarity shown. Then, during the comparatively long intervals between the input signal positive peaks, C_1 discharges through grid leak resistor R_1. This discharge current develops a direct voltage E_{R_1} such that the grid end of R_1 is negative with respect to the cathode or ground. Since the intervals between the positive peaks of the signal are long compared to the peak duration, most of the time the grid end of R_1 is negative with respect to ground. Thus, the average E_{R_1} is negative, its exact value depending upon the time constant R_1C_1 and the amplitude of the signal voltage e_i.

As shown by the wave-form of Figure 9A, the signal voltage e_i varies about an axis or zero voltage and, applied in series with C_1 and R_1, it alternately adds to and subtracts from the capacitor voltage to cause variations of the discharge current in grid resistor R_1. As a result, the wave-form of the instantaneous voltage e_g is applied to the grid as shown in Figure 10.

Another tube type commonly employed in the sync section is the 12AT7, a miniature, high-mu twin triode.

Courtesy General Electric Co.

The bias voltage E_{R_1} does not exist in the same form as a battery voltage but rather represents the average of all the instantaneous values of e_g, thus the axis of the input signal e_i coincides with the operating point of the tube.

With values of R_1 and C_1 that produce a comparatively long time constant, the intervals between sync pulses, when the capacitor discharges, are short. Therefore, the capacitor discharge maintains a relatively constant voltage across resistor R_1. In order that the tube cuts off at a relatively low negative grid voltage, the tube is operated at a low plate voltage. The signal level at which the tube cuts off is called the **clip level.** In Figure 9A, the dashed line indicates the clip level, and corresponds with that denoting cutoff in Figure 10. Under these conditions, only the synchronizing pulses reduce the negative grid voltage sufficiently to permit pulses of plate current.

As illustrated in Figure 10, this arrangement provides plate current pulses of the same waveform as the incoming synchronizing pulses. In any resistance coupled stage, the plate voltage is 180 degrees out of phase with the plate current. Therefore, as shown in the right of Figure 9C, the output voltage e_o consists of negative going synchronizing pulses.

Thus, the grid leak type of sync pulse separator consists of a triode or pentode tube with the circuit and input signal adjusted so that the "clip-level" falls near the base of the sync pulses of the video wave. Consequently, only the most positive portions of the complete signal, the synchronizing pulses, are able to produce plate current and appear in the output circuit.

#8

Diode Sync Separator

A diode type sync pulse separator is shown in Figure 11. Here, the plate is the input element, and the load resistor R_L is in the cathode circuit. When grid current occurs in a triode or pentode tube circuit, the effect often is referred to as the "diode action" between cathode and grid. Considering the circuit of Figure 11, the diode current develops a voltage across the resistor R_1 in the same way that the voltage E_{R_1} is produced in Figure 9B.

To review the diode action, during the positive alternations of the input voltage e_i in Figure 11, the cathode-to-plate electron flow charges capacitor C_1 to the polarity shown. Between these positive peaks, the charge on C_1 leaks through resistor R_1 to produce a voltage which causes the plate end of R_1 to be negative with respect to ground.

In order to pass only the synchronizing pulses of the input voltage e_i, the circuit must function with a clip level at the point indicated by the dashed line. As in the circuit of Figure 9B, the bias E_{R_1} in Figure 11 is dependent upon the amplitude of the input signal e_i and the time constant of R_1 and C_1. Thus, by using relatively large values of R_1 and C_1, and properly adjusting the amplitude of e_i, the voltage E_{R_1} can be made such that the diode plate is biased to or above the clip level.

Because of the negative bias E_{R_1}, the diode is nonconductive except during the intervals of the highly positive sync pulses and thus only these pulses cause diode current. During these synchronizing intervals, the electron flow through the low resistance of the diode and load resistor R_L is sufficiently large to recharge capacitor C_1 by an amount equal to that which leaks off through R_1 between pulses.

Developed by the diode current through R_L, the output signal voltage e_o has the shape of the sync pulses. However, neither inversion nor amplification takes place. As in any diode circuit, part of the input signal is across the tube, consequently the amplitude of the sync pulses in the diode clipper output is somewhat less than in the input. When the input to the circuit is sufficiently high, the diode clipper often is preferred since its output voltage wave-form contains less distortion than that of the triode or pentode types.

Noise Effects On Sync

Although the various video signal wave-forms shown contain only the desired picture, blanking, and sync components, in actual practice the receiving antenna picks up radiated energy from various nearby sources such as auto ignition systems, electric motors, and flashing signs. Called noise, this energy has the characteristics of pulses. Therefore, when added to the video signal and carried through the circuits of the receiver, it can affect the deflection circuits in a manner somewhat like that of the sync pulses.

However, since the noise pulses have various frequencies, they cause the deflection circuits to lose synchronism. The result on the screen is a jumbled pattern over several or all the lines due to horizontal sync loss, vertical rolling of the picture due to vertical sync loss, or both.

Similar effects occur if picture signal or blanking pulses pass through the sync circuits and are applied to the deflection circuits. Proper adjustment of the contrast control keeps the video signal below the level at which it can overdrive the sync separator, and thereby allows the separator to block the blanking pulse and picture signal components, but pass the relatively high amplitude sync pulses as explained.

If the amplitude of the noise pulses is below the clip level, Figures 9 and 11, then they are blocked by the separator circuit, the same as the picture and blanking components. However, noise pulses may have amplitude as great or even greater than that of the sync pulse. When this is the case, the noise pulses overcome the grid bias in Figure 9, or the diode plate bias in Figure 11, and cause the tube to conduct. As a result, the noise pulses are produced in the output of the separator circuit and applied to the deflection circuits to cause "loss of sync".

When the deflection oscillators are held in perfect synchronism by the received sync pulses, the reproduced picture is clear and stationary as shown here.

Courtesy Bendix Radio—
Div. of Bendix Aviation Corp.

Various methods are employed in receivers to prevent noise pulses passing to the deflection circuits. Although several methods are described in a following lesson, in one such arrangement, a single stage serves as both sync separator and noise cancelling circuit, as in Figure 12.

Pentagrid Sync Separator

Here, the pentagrid sync separator is designed to pass sync pulses only when there is no noise applied to its input. When noise is present, it cuts off the tube so that no signals whatever appear in the output. At these times, the stability of the deflection oscillators is relied upon to maintain synchronism.

As shown in Figure 12, there are two input signals applied to the circuit. A low amplitude video signal with negative going sync pulses is applied at point X and coupled through R_2 to grid No. 1. A large amplitude video signal with positive going sync pulses is applied at point Y and coupled through C_1 to grid No. 3. Thus, the plate current is controlled by signals applied to both of these grids. The signal at point X is the output of the video detector, and L_1 and R_1 constitute the video detector load circuit. The signal at point Y is obtained from the plate circuit of the video amplifier.

In this circuit, grid No. 3, the cathode, and the plate of tube V_1 perform the sync separating action in the same manner as the triode circuit of Figure 9. That is, the positive sync video signal at point Y drives the third grid slightly positive during the peaks of the sync pulses. Electron flow from the cathode to the third grid charges C_1 to the polarity indicated. Between pulses, C_1 discharges through R_5 to produce the grid leak bias E_{R_5}. This action biases the third grid beyond cutoff, a condition similar to that shown in Figure 10. Therefore, only the high amplitude sync pulses overcome this bias to permit conduction of plate current and produce the negative going sync pulse output e_o.

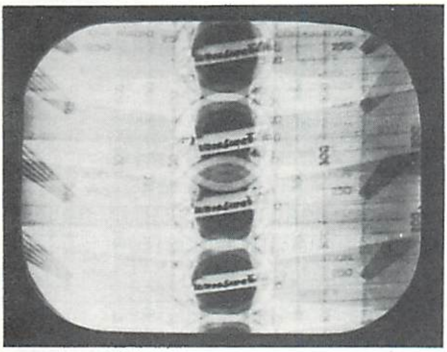
Tube V_1, employed in this circuit, is one of a number of types such as a 6CS6 or 6BE6 in which the high mu grid, grid No. 1, has a large control over the plate current when biased at or near zero with respect to the cathode. However, when this grid is raised beyond a certain amount positive, it has very little control, and acts merely as an accelerating electrode. In Figure 12, R_3, R_2, L_1, and R_1 form a voltage divider from B+ to ground. The resistance of R_3 is considerably greater than the total resistance of the other three components. Therefore, a small positive voltage is applied from the junction of R_2 and R_3 to grid No. 1 of V_1. This positive voltage is high enough, however, so that this grid loses almost all control of the plate current. As a result, the low amplitude video signal has almost no effect on the plate current which, as explained, is controlled by grid No. 3.

Due to rectification by the video detector, noise pulses in its output have negative polarity only, the same as the video signal shown at point X. The high amplitude negative noise voltages applied at point X drive the first grid negative and cut the tube off. These noise pulses are positive at point Y, but with the tube cut off by the first grid, there can be no plate current. Therefore, neither noise nor sync pulses are produced in the output of the sync separator during the time the noise voltage is present in the video detector output. Thus, during noise signals, the receiver is held in sync by its deflection oscillators.

Sync Amplifiers

The complete sync section contains a sync separator, usually one of the types described, plus one or more amplifier stages. The amplifier may serve any or all of a number of purposes in the various receivers. When the sync pulse output of the separator is not large enough in amplitude to properly synchronize the deflection circuits, the sync amplifier increases the voltage level of the pulses.

Employing either a triode or pentode tube, usually the sync amplifier circuit operates with grid leak bias and low plate voltage similar to Figure 9B. Operated in this manner, the amplifier has a relatively small range over which the plate current can vary between saturation and cutoff. As a result, it clips both the positive and negative peaks of the pulse signal to block the passage of noise voltages which may exist. Due to this action, the sync amplifier often is referred to as a limiter or clipper. Because of the 180° phase difference between the plate and grid voltages, the sync amplifier serves also as a phase inverter where positive pulses are required. If amplified pulses of both phases are needed, part of the load, R_L, is placed in the cathode circuit, and the stage operated as a phase splitter.



When noise pulses or other effects cause the vertical deflection oscillator to lose synchronism, the picture rolls vertically on the screen as shown here.

Courtesy Capehart-Farnsworth Company

SYNC PULSE FILTER CIRCUITS

In addition to separating the sync pulses from the composite video signal, and amplifying, clipping, and inverting them, the sync circuits contain RC filters designed so that only pulses of the horizontal scanning frequency are applied to the horizontal deflection circuit and pulses of the field frequency are applied to the vertical deflection circuit. As shown in the composite video wave-form, Figure 2, three distinct types of synchronizing pulses are transmitted along with the picture signals and blanking pulses. These types are the horizontal sync pulses, vertical sync pulses, and equalizing pulses.

Although these sync pulses are of the same magnitude, they are of different durations. Therefore, when applied to an RC filter circuit, the pulses are segregated according to their duration and applied to the proper deflection generator to maintain a constant frequency relation between the generator output and the appropriate sync pulses.

5 microsecond long pulses are used for synchronizing the hori-

zontal deflection generator, the oscillation frequency of which is 15,750 cycles per second. Each of the six vertical sync pulses are 27 microseconds in length, and are separated by 4.5 microsecond intervals. Altogether, the six pulses occupy $6 \times 27 = 162$ microseconds, and the five intervals occupy $5 \times 4.5 = 22.5$ microseconds. Thus, the total time for the vertical sync pulses is $162 + 22.5 = 184.5$ microseconds. Therefore, so far as the vertical sync action is concerned, the six vertical sync pulses are considered as one long pulse with a duration of 184.5 microseconds. This pulse is employed for synchronizing the vertical deflection generator, the oscillation frequency of which is 60 cycles per second. Groups of six equalizing pulses, before and after the vertical sync pulses, insure proper synchronization of the vertical oscillator.

Differentiating Circuit

To separate or segregate the higher frequency horizontal sync pulses from the lower frequency vertical sync pulses, it is customary to employ a high pass or DIFFERENTIATING NETWORK like Figure 13A. With this arrangement, the composite wave containing all three kinds of sync pulses is impressed across the series RC circuit, with the output appearing across the resistor. Figure 13B represents the narrow horizontal sync pulses, while Figure 13C represents part of the long vertical sync pulse. To maintain synchronization of the horizontal oscillator during the vertical sync pulse interval, this long pulse is broken up by SERRATIONS into six closely spaced pulses which are longer than the horizontal sync pulses.

For proper operation of the differentiating network, the resistance and capacitance are chosen so that the time constant is short compared with the duration of the horizontal pulses. Hence, the capacitor can charge and discharge rapidly so that, appearing across the resistor, output voltage E_{R_1} has the wave-form of the sharp pointed pulses illustrated in Figures 13D and 13E.

Due to the short RC time constant, the action of the filter circuit is about the same for the widely spaced, narrow pulses of Figure 13B as it is for the closely spaced, wider pulses of Figure 13C. In either case, the output waves are about alike and of the proper shape to control the horizontal deflection circuits.

The deflection circuit oscillators operate in such a way that their oscillations can take place only at or very near the frequency to which they are "tuned". Therefore they can be controlled only by pulses which occur at or near their natural frequency, or which occur at some whole number multiple of their natural frequency.

The horizontal deflection oscillator is adjusted to operate at the frequency of the horizontal sync pulses of Figure 13B. Since the pulses of Figure 13E occur at twice this frequency, only every other one of these controls the horizontal oscillator.

The 2.5 microsecond equalizing pulses which occur immediately before and after the vertical sync pulses also have twice the frequency of the horizontal pulses. At the output of the filter, their wave-form is similar to those of Figure 13D, but they occur at twice the horizontal sweep frequency. Again, only every other pulse "trips" the horizontal oscillator. Thus, although several sync signals are being received, the output of the filter of Figure 13A provides continuous control of the horizontal deflection circuit.

As pointed out earlier, for the differentiating circuit to function as explained for Figure 13, it is necessary that its RC time constant be relatively short, a recommended value being one-half of one percent of the interval between pulses. Because of the loading effect on the tube circuits to which the differentiating circuits are connected, some receiver designs employ more than one such RC circuit. Each has a somewhat longer time constant so that the differentiation of the synchronizing pulses is accomplished by the combined action of the several filters.

Integrating Circuit

For separating the low frequency vertical sync pulses from the high frequency horizontal sync pulses, the low pass or integrating network shown in Figure 14A is employed. With this arrangement, the composite sync signal is impressed across the series RC circuit, and the output appears across the capacitor. As in the case of the differentiating circuit, the desired operating characteristics are obtained by using the correct time constant.

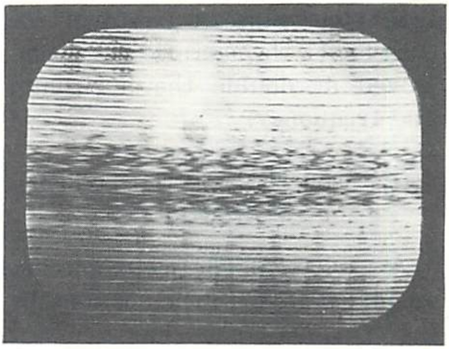
In order to separate the horizontal sync pulses shown in Figure 14B from the vertical pulse of Figure 14C, this time constant should be approximately one-fifth of the vertical pulse duration.

The sync signal input to the integrating circuit contains both the horizontal pulses, Figure 14B, and the vertical pulses, Figure 14C. When a narrow horizontal pulse is applied to the filter, the capacitor begins to charge through the resistor, as shown in Figure 14D. However, before the charge becomes very high, the trailing edge of the input pulse arrives, and the capacitor discharges completely before the next pulse arrives.

On the other hand, when a wide vertical pulse is applied to the RC network, the capacitor is charged for a longer period of time and therefore to a higher potential, as shown from points 1 to 2, Figure 14E. During the short gap or serration between the first and second parts of the vertical pulse, the capacitor discharges to a slightly lower potential, points 2 to 3, but the following pulse causes it to charge from point 3 up to point 4.

Again it discharges slightly between pulses and is then charged further by each succeeding segment of the vertical pulse. Because of the relatively long duration and close spacing of these segments of the vertical sync pulse, during the vertical synchronizing pulse interval the capacitor is charged more than it is allowed to discharge. As a result the capacitor voltage builds up until it reaches a maximum, such as point X in Figure 14E, at the end of the vertical sync pulse. After the vertical sync interval, the capacitor is allowed to discharge to the zero level.

The group of six segments which constitute the vertical sync pulse occur once every 60th of a second, thus the wave of Figure 14E is produced every 60th of a second and, in the form of one large pulse, is used to synchronize the vertical deflection circuit. As shown by the curve of Figure 14D, the voltages produced across the capacitor by the horizontal synchronizing pulses are of relatively low amplitude and, therefore, have little or no effect on the vertical oscillator.



Loss of synchronism by the horizontal deflection oscillator may cause the picture to break up completely.

Courtesy Capehart-Farnsworth Company

So far as vertical synchronization is concerned, the separate pulses of Figure 14C could be combined into one long pulse which would eliminate the serrations of Figure 14E. However, while they have no function in the vertical deflection circuit, these interruptions are necessary to maintain synchronization of the horizontal deflection oscillator during the vertical synchronizing interval, as explained for Figure 13C.

The serrations could occur at the scanning line frequency instead of twice the line frequency. However, as shown in Figure 8B, the first, third, and fifth vertical sync pulses start the horizontal flyback action in one field, while the second, fourth, and sixth pulses sync the horizontal generator for the next field, as shown in Figure 8A. Therefore, to permit transmitting the same vertical sync pulse wave-form for both fields, the serrations are employed at double the horizontal line frequency.

SEPARATOR AND FILTER CIRCUIT

A variety of arrangements are employed in the sync sections by the various television receiver manufacturers. Unfortunately, there is no strict standardization in the industry with regard to the names given to the various stages in the sync section. For example, although most manufacturers refer to the circuits of Figures 9, 11, and 12 as the sync separator, you may encounter commercial schematic diagrams on which this stage is called a clipper or sync stripper.

In some cases, the separating, inverting, clipping, and amplifying of the pulses is completed before they are applied to the RC filters. In other receivers, the composite sync pulse output of the sync separator is applied to the differentiating and integrating circuits, with their respective high and low frequency pulse outputs amplified and clipped by separate sync amplifiers. The latter arrangement is used in the example of a complete sync circuit given in Figure 15.

In this circuit, diode V_1, the video detector, is connected so as to deliver a negative signal to the grid of tube V_2 as shown by the wave-form at the lower left of the Figure. Connected between V_1 and its load resistor R_1, the low-pass filter L_1, C_1, L_2, and C_2 maintains the detector frequency response constant up to about 4 mc.

Series compensated by L_3 and R_3, and shunt compensated by L_4, V_2 amplifies the complete or composite video signal and applies it through capacitor C_6 to the cathode of the picture tube as indicated at the upper center of the Figure. Appearing at the junction of L_4 and R_4 as well as on the V_2 plate and picture tube cathode, the V_2 output has the wave-form shown above V_2.

From the L_4R_4 junction, the composite video signal is applied through isolation resistor R_8 and coupling capacitor C_7 to the V_3 control grid. In this control grid circuit, C_7 and R_9 form a differentiating network similar to the one of Figure 13A. However, the RC time constant must be very long so that the shape of the composite video wave-form is not changed.

Operated with very low plate and screen grid voltages because of voltage divider $R_{10}R_{12}$, and with grid leak bias developed across R_9, V_3 functions as explained for Figure 9 to remove the sync pulses from the applied signal.

During the synchronizing intervals, the sync pulses drive the V_3 control grid positive, causing a grid current that quickly charges C_7 to the input peak value. Between sync pulses, the long R_9C_7 time constant keeps the capacitor from discharging appreciably and the negative direct voltage developed across R_9 remains essentially constant nearly equal to the peak value of the pulse.

Due to the very low plate and screen grid potentials, plate current cutoff is reached with a low negative grid bias. Thus, V_3 is biased well beyond cutoff so that only the sync pulse tips can overcome the bias and cause plate current. The resulting plate voltage wave-form consists of negative pulses as shown by the wave-form at the upper right. Although not shown in Figure 15, the vertical sync and equalizing pulses, as well as the horizontal sync pulses are present in the composite video wave which appears in the V_3 plate circuit.

From the plate of V_3, the composite sync signal is coupled through C_{10} to the grid of the horizontal sync amplifier, V_4. Having a short RC time constant, the differentiating network, $C_{10}R_{13}$ in the grid circuit of V_4, changes the rectangular pulses into peaked pulses or "pips" which then are amplified by V_4, the output wave-form of which is indicated.

For convenience of the viewer, this television receiver is designed with its operating controls at the top of the cabinet. Often, an adjustment of the contrast control restores picture stability when slight loss of synchronism is present.

Courtesy Raytheon Mfg. Co.—
TV & Radio Operations

The amplitude difference between the positive and negative pips of the output is due to the fact that V_4 is operated without fixed bias. At the beginning of the sync pulse, the sudden drop of V_3 plate potential causes C_{10} to discharge rapidly through R_{13}, producing a large negative "pip" on the V_4 grid.

When the V_3 plate voltage rises suddenly at the end of the sync pulse, the grid of V_4 is driven positive and grid current rapidly charges C_{10}. However, due to the very low cathode to grid resistance when there is grid current, the positive pip is of very small amplitude. Amplified and inverted by tube V_4, the differentiated sync pulse consists of a large amplitude positive pip and a low amplitude negative pip as shown.

Also from the plate of V_3 and coupled through the d-c blocking capacitor C_9, the composite sync signal is applied to the input of the three section RC integration network $R_{14}C_{11}$, $R_{15}C_{12}$ and $R_{16}C_{13}$. The output of this network is amplified by V_5 and applied to the vertical deflection circuit. By using three of the Figure 14A networks connected end to end, the integration network of Figure 15 filters out all traces of the horizontal sync and equalizing pulses as well as most noise signals that could cause improper operation of the vertical deflection generator.

Completing the V_5 grid circuit, R_{17} is returned to the plate supply source to provide a path for discharging the network capacitors quickly. At first glance, it might seem that the V_5 control grid is at the plate supply potential. However, with the grid positive with respect to the cathode, there is grid current. Electrons flow from cathode to grid, through R_{17} and R_{12} to "Low B+". The cathode-grid resistance of the tube is very low compared with the resistance of R_{17} and R_{12}. Therefore, nearly the entire B+ voltage appears across these two resistors in series so that the grid of V_5 is only slightly positive with respect to the cathode.

The horizontal sync pulses applied to the first section of the integration network of Figure 15 cause C_{11} to charge slightly as explained for the circuit of Figure 14A and illustrated in Figures 14B and 14D. However, in this case, the pulses are negative and Figures 14B and 14D should be inverted to show the true C_{11} wave-form. The C_{11} voltage is applied to the second section, charging C_{12} to a small portion of the C_{11} voltage. Applied to the third section, the C_{12} voltage charges C_{13} slightly. In practice, the input pulse amplitude is kept relatively small, so that the horizontal sync pulses have practically no effect on the C_{13} charge.

During the vertical synchronizing interval, the six comparatively long pulses applied to the network input charge C_{11} as explained for Figure 14A and illustrated by Figures 14C and 14E. Here again, the curves of Figures 14C and 14E must be inverted to show the true wave-forms of Figure 15. Applied to the second section, the C_{11} voltage charges C_{12} and, in turn, C_{13}. Because of the RC time constants, the charge on C_{13} is considerably lower than on C_{11} but the unevenness due to the serrations is removed almost completely.

To insure proper synchronizing of the vertical deflection oscillator, the trailing edge of the C_{13} voltage pulse is steepened through the action of R_{17}. At the end of the vertical sync interval, the excess electrons on the ungrounded plates of C_{11}, C_{12}, and C_{13}, flow through R_{17}, R_{12} and the low B+ supply to ground and from ground to the lower capacitor plates, thus discharging the capacitors very rapidly. The integrated vertical sync pulse is amplified by V_5. Then, with the wave-form shown above C_{14}, the pulse is applied to the deflection generator.

In this lesson we have explained the relationships between the horizontal and vertical deflection motions of the electron beam in the picture tube and the synchronizing signals which are transmitted as part of the composite video signal. Also, we have described the operation of the circuits which separate the sync signals from the picture and blanking portions of the video signal. Although one example of a complete sync circuit has been given in Figure 15, there exists a considerable variety of sync circuit arrangements, as mentioned. Therefore, in the next lesson, we describe a number of typical sync circuits as employed in various commercial television receivers.

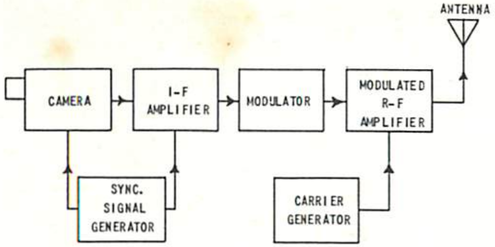


FIGURE 1

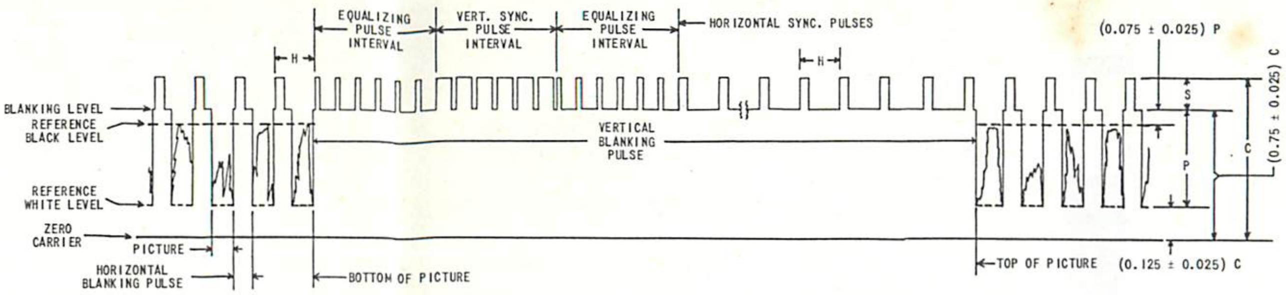


FIGURE 2

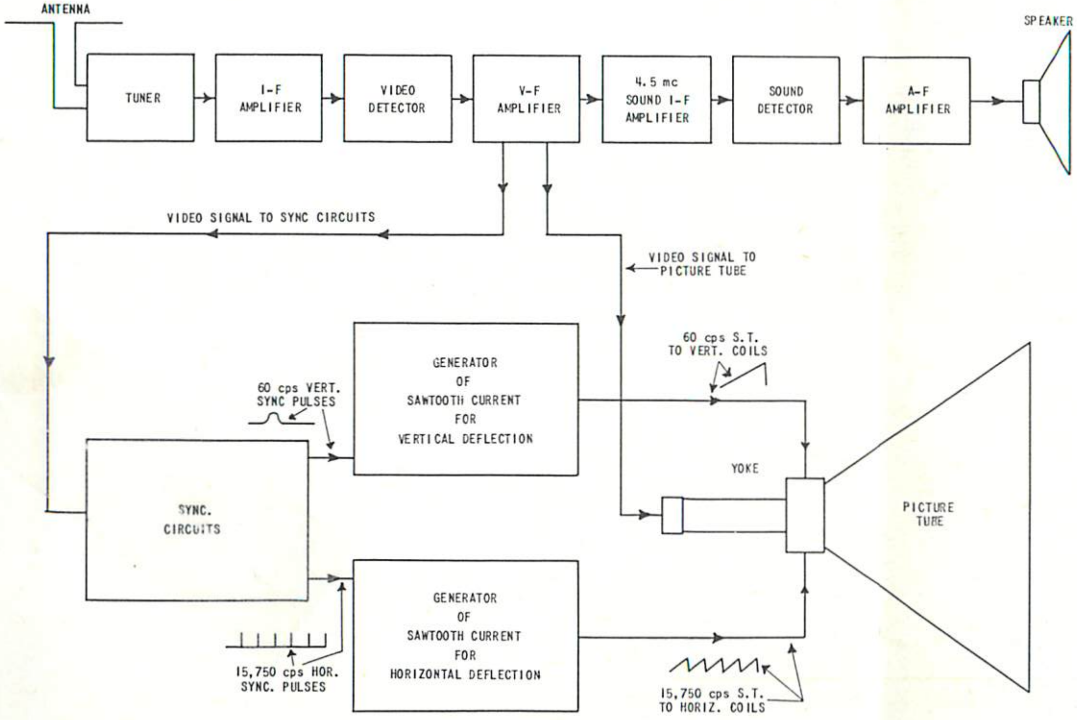

ANTENNA
TUNER
I-F AMPLIFIER
VIDEO DETECTOR
V-F AMPLIFIER
4.5 mc SOUND I-F AMPLIFIER
SOUND DETECTOR
A-F AMPLIFIER
SPEAKER
VIDEO SIGNAL TO SYNC CIRCUITS
VIDEO SIGNAL TO PICTURE TUBE
60 cps VERT. SYNC PULSES
GENERATOR OF SAWTOOTH CURRENT FOR VERTICAL DEFLECTION
60 cps S.T. TO VERT. COILS
SYNC. CIRCUITS
YOKE
PICTURE TUBE
GENERATOR OF SAWTOOTH CURRENT FOR HORIZONTAL DEFLECTION
15,750 cps HOR. SYNC. PULSES
15,750 cps S.T. TO HORIZ. COILS

FIGURE 3

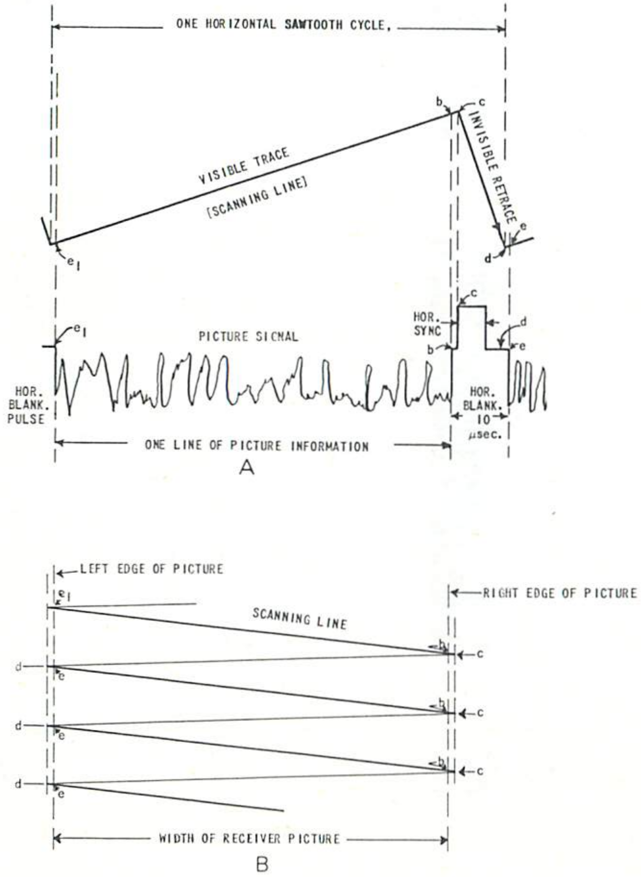


FIGURE 4

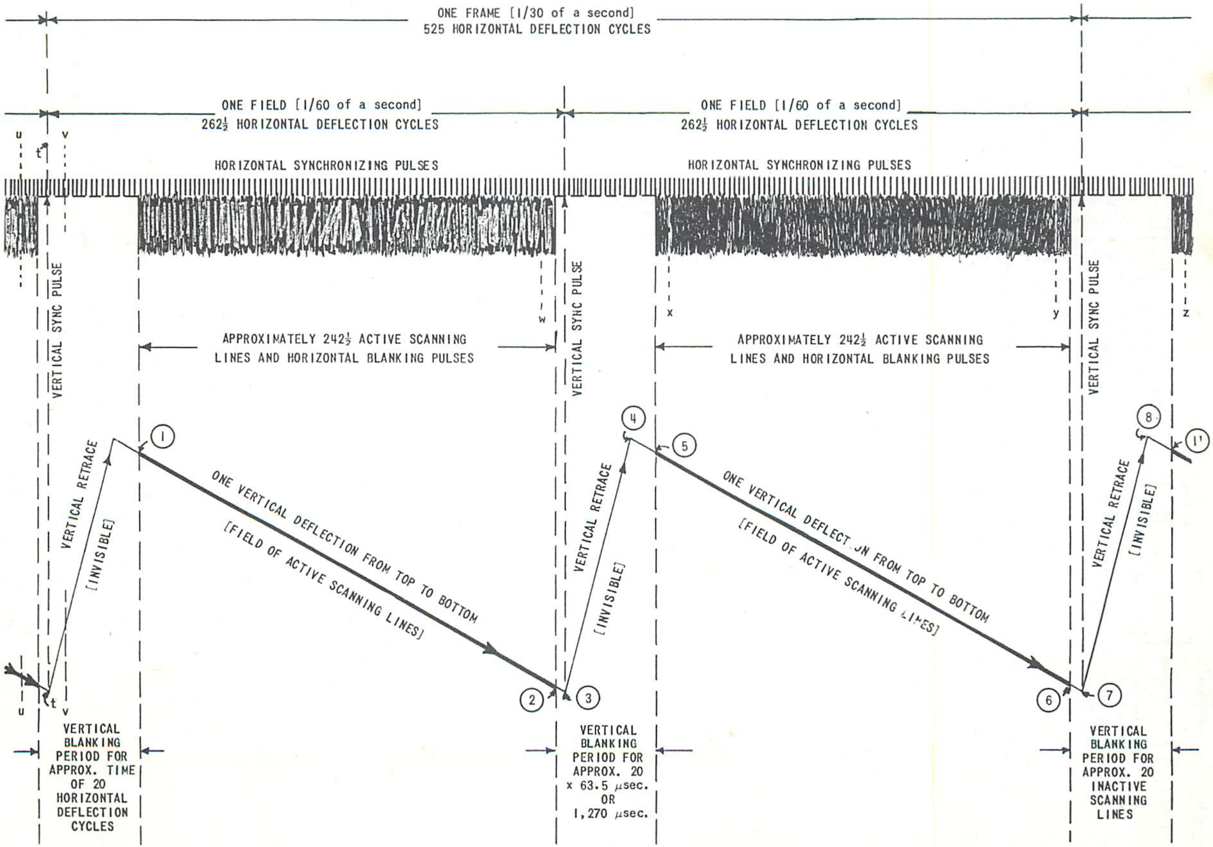

ONE FRAME [1/30 of a second]
525 HORIZONTAL DEFLECTION CYCLES
ONE FIELD [1/60 of a second]
262½ HORIZONTAL DEFLECTION CYCLES
ONE FIELD [1/60 of a second]
262½ HORIZONTAL DEFLECTION CYCLES
u
t'
v
HORIZONTAL SYNCHRONIZING PULSES
HORIZONTAL SYNCHRONIZING PULSES
VERTICAL SYNC PULSE
VERTICAL SYNC PULSE
VERTICAL SYNC PULSE
w
x
y
z
APPROXIMATELY 242½ ACTIVE SCANNING LINES AND HORIZONTAL BLANKING PULSES
APPROXIMATELY 242½ ACTIVE SCANNING LINES AND HORIZONTAL BLANKING PULSES
VERTICAL RETRACE
[INVISIBLE]
①
ONE VERTICAL DEFLECTION FROM TOP TO BOTTOM
[FIELD OF ACTIVE SCANNING LINES]
②
③
VERTICAL RETRACE
[INVISIBLE]
④
⑤
ONE VERTICAL DEFLECTION FROM TOP TO BOTTOM
[FIELD OF ACTIVE SCANNING LINES]
⑥
⑦
VERTICAL RETRACE
[INVISIBLE]
⑧
1'
u
t
v
VERTICAL BLANKING PERIOD FOR APPROX. TIME OF 20 HORIZONTAL DEFLECTION CYCLES
VERTICAL BLANKING PERIOD FOR APPROX. 20 x 63.5 μsec. OR 1,270 μsec.
VERTICAL BLANKING PERIOD FOR APPROX. 20 INACTIVE SCANNING LINES

FIGURE 6

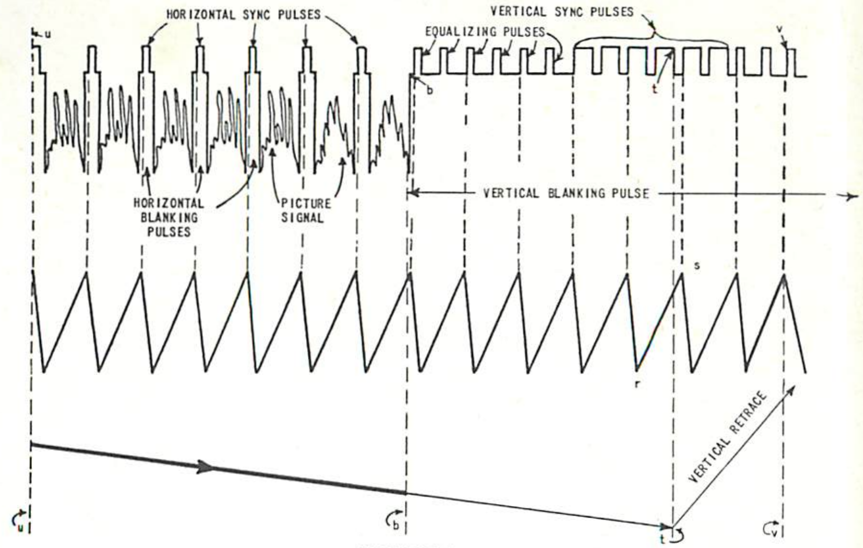


FIGURE 5

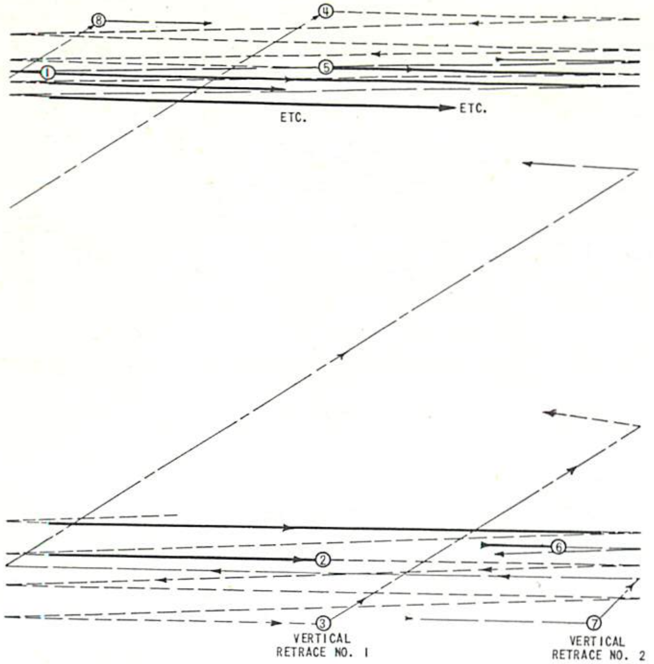


FIGURE 7

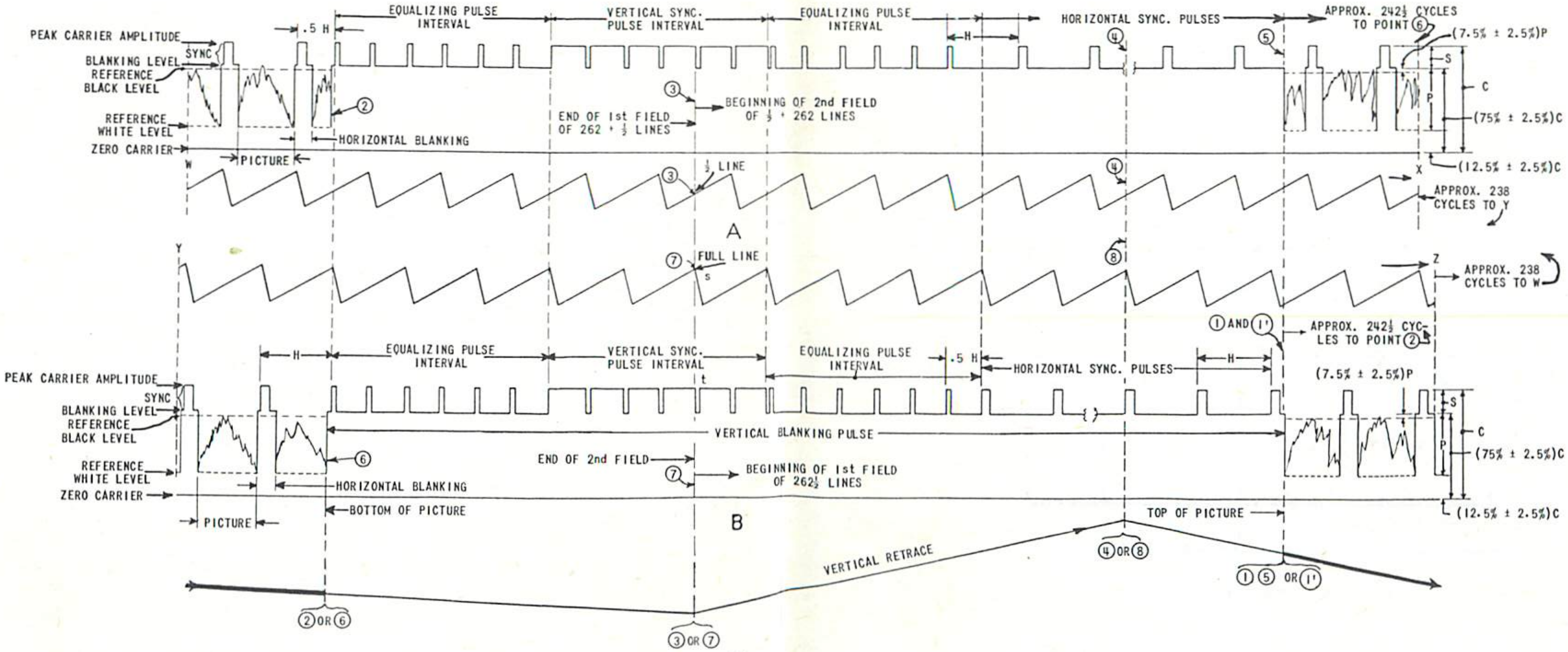


FIGURE 8

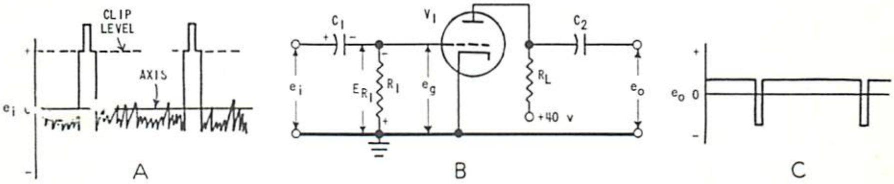


FIGURE 9

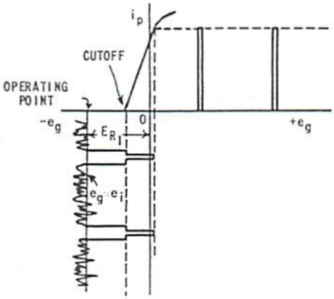


FIGURE 10

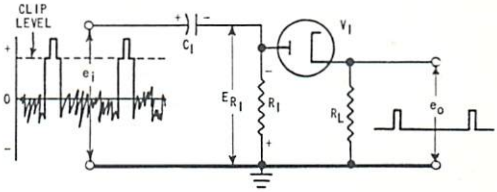


FIGURE 11

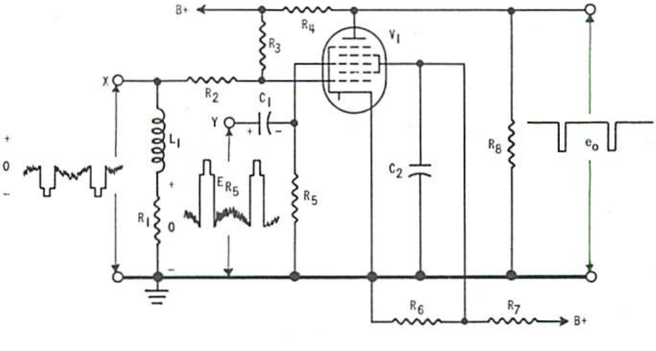


FIGURE 12

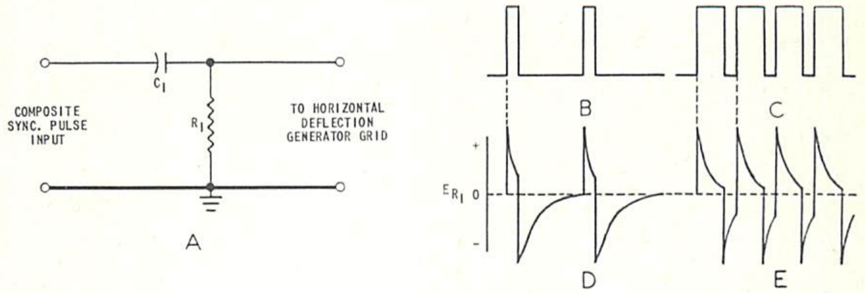

C1
COMPOSITE SYNC. PULSE INPUT
R1
TO HORIZONTAL DEFLECTION GENERATOR GRID
A
B
C
+
ER1 0
-
D
E

FIGURE 13

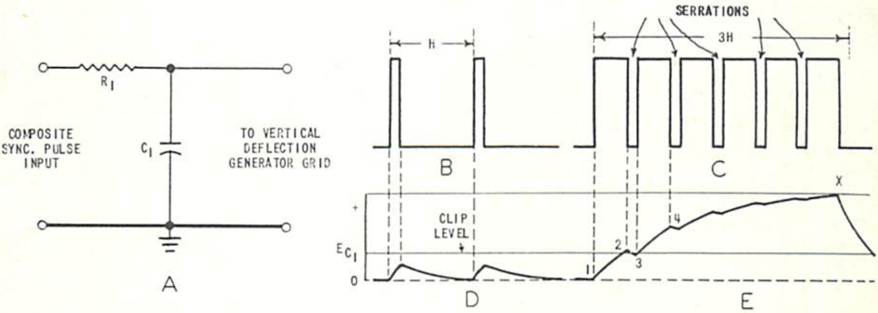

R1
COMPOSITE SYNC. PULSE INPUT
C1
TO VERTICAL DEFLECTION GENERATOR GRID
A
H
SERRATIONS
3H
B
C
X
+
CLIP LEVEL
EC1
0
1
2
3
4
D
E

FIGURE 14

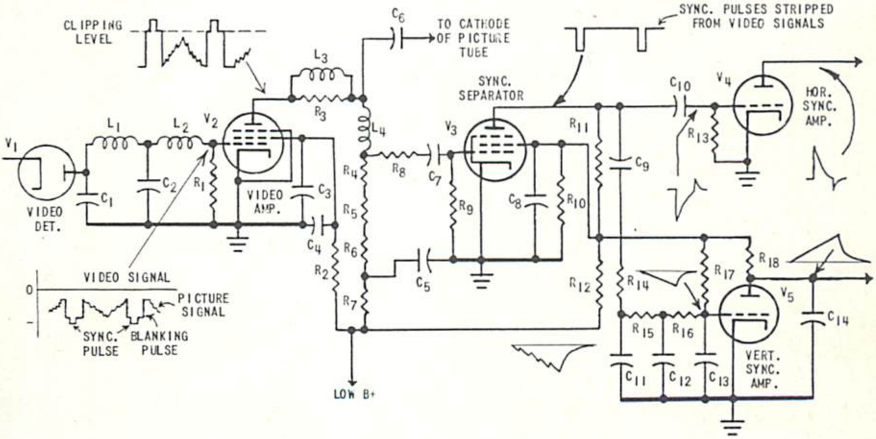


FIGURE 15

FROM OUR *Director's* NOTEBOOK

MY OBJECTIVE

To make myself ready, so that Opportunity will not pass me by.

To stir my mind with effort.

To do the rational things without being told.

To make every hour bring increased knowledge, and never let time find me idle.

To study my profession with unremitting zeal.

To convert practice and experience into capital stock for future use.

To be honest and generous.

To banish a morose temper for one bright and equable.

To attain an agreeable personality, and be esteemed.

To be gentle both to my superiors and to my inferiors.

To make the most of myself with the hope of achieving the greatest of all rewards—a good conscience.

Yours for success,

W. C. DeVry

DIRECTOR

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